

Carbohydrate Metabolism

Lectures (1-5)

Marks' Basic medical
biochemistry
14 questions



USMLE step 1 (FIRST AID)
3 questions



Lippincott's Illustrated
review of Biochemistry
9 questions



Various sources
15 questions from:
Mutah's past/ JUST's past
OMC's past/ Online resources

Link for feedback if there's any question wrong: [**FEEDBACK FORM**](#)

CAUTION!! There are some hard questions but with some really good comprehensive ideas, I'll emphasize them with the word **Hard**. Focus and don't down yourself if you get any question wrong.

GOOD LUCK!

Q1: the facilitative transporter that is most responsible for transporting fructose from the blood into cells is which of the following

- A) GLUT 1
- B) GLUT 2
- C) GLUT 3
- D) GLUT 4
- E) GLUT 5

ANSWER: E

Hard

Q2: patient with alcoholism developed pancreatitis that affected his exocrine pancreatic function. He exhibited discomfort after eating a high-carbohydrate meal. The patient most likely had a reduced ability to digest which of the following?

- A) Starch
- B) Lactose
- C) Fiber
- D) sucrose
- E) Maltose

ANSWER: A

Why? The pancreas produces α -amylase, which digests starch in the intestinal lumen. If pancreatic α -amylase cannot enter the lumen because of pancreatitis, the starch will not be digested to a significant extent. (The salivary α -amylase begins the process, but only for the time during which the food is in the mouth, because the acidic conditions of the stomach destroy the salivary activity.) The discomfort arises from the bacteria in the intestine digesting the starch and producing acids and gases. Lactose, sucrose, and maltose are all disaccharides that would be cleaved by the intestinal disaccharidases located on the brush border of the intestinal epithelial cells (thus, B, D, and E are incorrect). These activities might be slightly reduced because the pancreas would also have difficulty excreting bicarbonate to the intestine, and the low pH of the stomach contents might reduce the activity of these enzymes. However, these enzymes are present in excess and will eventually digest the disaccharides. Fiber cannot be digested by human enzymes, so answer C is incorrect.

Hard

Q3: A patient has a genetic defect that causes intestinal epithelial cells to produce disaccharidases of much lower activity than normal. Compared with a normal person, after eating a bowl of oatmeal and milk sweetened with table sugar, this patient will exhibit higher levels of which of the following?

- A) Maltose, sucrose, and lactose in the stool
- B) Starch in the stool
- C) Galactose and fructose in the blood
- D) Glycogen in the muscles
- E) Insulin in the blood

ANSWER: A

The why, Salivary and pancreatic α -amylase will partially digest starch to glucose, but maltose and disaccharides will pass through the intestine and exit with the stool as a result of the limited activity of the brush-border enzymes. Because the amylase enzymes are working, there will only be normal levels of starch in the stool (thus, B is incorrect). Not all available glucose is entering the blood, so less insulin will be released by the pancreas (thus, E is incorrect), which will lead to less glucose uptake by the muscles and less glycogen production (thus, D is incorrect). Because neither lactose nor sucrose can be digested to a large extent in the intestinal lumen under these conditions, it would be difficult to have elevated levels of galactose or fructose in the blood (thus, C is incorrect).

Q4:Glucose is the body's universal fuel, which can be used by virtually all tissues. A major role of glycolysis is which one of the following?

- A) To synthesize glucose
- B) To generate energy
- C) To produce FAD(2H)
- D) To synthesize glycogen
- E) To use ATP to generate heat

ANSWER: B

Q5: Glycolysis generates energy such that cells have a source of energy to survive. Starting with glyceraldehyde 3-P and synthesizing one molecule of pyruvate, the net yield of ATP and NADH would be which one of the following?

- A) 1 ATP, 1 NADH
- B) 1 ATP, 2 NADH
- C) 1 ATP, 4 NADH
- D) 2 ATP, 1 NADH
- E) 2 ATP, 2 NADH
- F) 2 ATP, 4 NADH
- G) 3 ATP, 1 NADH
- H) 3 ATP, 2 NADH
- I) 3 ATP, 4 NADH

ANSWER: D

Q6: Every human cell has the capacity to use glycolysis for energy production. Which one of the following statements correctly describes an aspect of glycolysis?

- A) ATP is formed by oxidative phosphorylation.
- B) Two molecules of ATP are used in the beginning of the pathway.
- C) Pyruvate kinase is the rate-limiting enzyme.
- D) One molecule of pyruvate and three molecules of CO₂ are formed from the oxidation of one glucose molecule.
- E) The reactions take place in the matrix of the mitochondria.

ANSWER: B

Q7: Because glucose has several metabolic routes it might take once it arrives in the cytoplasm, which one of the following reactions would commit the glucose to following the glycolytic pathway?

- A) Glucose to glucose 1-P
- B) Glucose to glucose 6-P
- C) Fructose 6-P to fructose 1,6-bisP
- D) Fructose 1,6-bisP to dihydroxyacetone phosphate and glyceraldehyde 3-P
- E) Glucose 1-P to glucose 6-P

ANSWER: C

Q8: The red blood cells require ATP in order to maintain ion gradients across their membrane. In the absence of these ion gradients, the red blood cells will swell and burst, bringing about a hemolytic anemia. Red cells generate their energy via which one of the following?

- A) Substrate-level phosphorylation
- B) TCA cycle
- C) Oxidative phosphorylation
- D) Electron transfer to oxygen
- E) Oxidation of glucose to CO₂ and H₂O

ANSWER: A

Q9: Under conditions of glucagon release, the degradation of liver glycogen normally produces which one of the following?

- A) More glucose than glucose 1-P
- B) More glucose 1-P than glucose
- C) Equal amounts of glucose and glucose 1-P
- D) Neither glucose nor glucose 1-P
- E) Only glucose 1-P

ANSWER: B

Q10: An adolescent patient with a deficiency of muscle phosphorylase was examined while exercising her forearm by squeezing a rubber ball. Compared with a normal person performing the same exercise, this patient would exhibit which one of the following?

- A) Exercise for a longer time without fatigue
- B) Have increased glucose levels in blood drawn from her forearm
- C) Have decreased lactate levels in blood drawn from her forearm
- D) Have lower levels of glycogen in biopsy specimens from her forearm muscle
- E) Hyperglycemia

ANSWER: C

McArdle disease

Q11: In a glucose tolerance test, an individual in the basal metabolic state ingests a large amount of glucose. If the individual is normal, this ingestion should result in which one of the following?

- A) An enhanced glycogen synthase activity in the liver
- B) An increased ratio of glycogen phosphorylase a to glycogen phosphorylase b in the liver
- C) An increased rate of lactate formation by red blood cells
- D) An inhibition of PP-1 activity in the liver
- E) An increase of cAMP levels in the liver

ANSWER: A

Q12: Assume that an individual carries a mutation in muscle PKA such that the protein is refractory to high levels of cAMP. Glycogen degradation in the muscle would occur, then, under which one of the following conditions?

- A) High levels of intracellular calcium
- B) High levels of intracellular glucose
- C) High levels of intracellular glucose 6-P
- D) High levels of intracellular glucose 1-P
- E) High levels of intracellular magnesium

ANSWER: A

Ca²⁺ - Calmodulin

Q13: A patient has been diagnosed with a glucagonoma, a pancreatic tumor that independently and episodically secretes glucagon. Which one of the following would be expected in this patient?

- A) Low serum glucose
- B) Increased glycogenolysis in the liver
- C) Increased glycogenolysis in muscle tissue
- D) Increased glycogenesis in the liver
- E) Increased glycogenesis in muscle tissue

ANSWER: B

Cytology question, but it's good.

Q14: The mechanism through which Ras becomes an oncogenic protein is which one of the following?

- A) Ras remains bound to GAP
- B) Ras can no longer bind cAMP
- C) Ras has lost its GTPase activity
- D) Ras can no longer bind GTP
- E) Ras can no longer be phosphorylated by MAP kinase

ANSWER: C

Q15: A 6-year-old boy is brought to his pediatrician's office by his parents, who report that the child has been unusually thirsty for the past week. He also has increased urinary frequency and has wet the bed three times in the past two weeks. A random blood glucose level is 215 mg/dL. The pediatrician suspects that the child has type 1 diabetes mellitus caused by autoimmune destruction of insulin-producing pancreatic b cells. Which of the following is the transporter for glucose to enter pancreatic b cells?

- A) GLUT 1
- B) GLUT 2
- C) GLUT 4
- D) Simple diffusion

Q16: Which of the following enzymes catalyzes high-energy phosphorylation of substrates during glycolysis?

- A) Pyruvate kinase
- B) Phosphoglycerate kinase
- C) Triose phosphate isomerase
- D) Aldolase
- E) Glyceraldehyde-3-phosphate dehydrogenase

ANSWER: E

High energy phosphate bonds are added to the substrates of glycolysis at three steps in the pathway. Hexokinase—or, in the case of the liver, glucokinase— adds phosphate from ATP to glucose to form glucose-6-phosphate. Strictly speaking, this is not always considered a step of the glycolytic pathway. Phosphofructokinase uses ATP to convert fructose-6-phosphate to fructose-1, 6-phosphate. Using NAD⁺ in an oxidation-reduction reaction, inorganic phosphate is added to glyceraldehyde-3-phosphate by the enzyme glyceraldehyde-3-phosphate dehydrogenase to form 1,3-diphosphoglycerate. The enzymes phosphoglycerate kinase and pyruvate kinase transfer substrate high-energy phosphate groups to ADP to form ATP.

Q17: Which of the following is most likely to be seen in Fasting State?

- A) A decrease in glucagon activity
- B) Increased activity of cyclic AMP
- C) Increase glycolytic activity
- D) A decrease in insulin activity

ANSWER: B

Q18: Anaerobiosis leads to lactate formation in muscle due to which one of the following?

- A) Inhibiting hexokinase by glucose-6-phosphate
- B) Providing 2,3-bisphosphoglycerate for the phosphoglycerate mutase reaction
- C) Inhibiting pyruvate kinase by pyruvate
- D) Providing substrate for glyceraldehyde-3-phosphate dehydrogenase
- E) Inhibiting phosphofructokinase-1 by AMP

ANSWER: D

Q19: In muscle, under anaerobic conditions, the net synthesis of ATP starting from one mole of glucose derived from muscle glycogen is which one of the following? (remember that glucose is cleaved from glycogen as G6P)

- A) 1 mole of ATP
- B) 2 moles of ATP
- C) 3 moles of ATP
- D) 4 moles of ATP
- E) 5 moles of ATP

ANSWER: C

Q20: Under conditions of hypoglycemia, the liver is not utilizing glucose as an energy source due to which of the following?

- A) A low K_m for glucokinase
- B) A high K_m for glucokinase
- C) An inhibited, phosphorylated PFK-1
- D) An activated, phosphorylated PFK-1
- E) A reduction of glucose transporters in the membrane

ANSWER: B

Hard

Q21: A 3-month-old infant was brought to the pediatrician due to muscle weakness (myopathy) and poor muscle tone (hypotonia). Physical exam revealed an enlarged liver and heart, and heart failure. The infant had always fed poorly, had failure to thrive, and had breathing problems. He also had trouble holding up his head. Blood work indicated early liver failure. A liver biopsy indicated that glycogen was present and of normal structure. A potential defect in this child is which of the following?

- A) Liver glycogen phosphorylase
- B) Liver glycogen synthase
- C) Liver α -(1-4) glucosidase
- D) Liver debranching enzyme
- E) Liver branching enzyme

ANSWER: C

REMEMBER: Pompe disease affects muscle, heart and liver. And is characterized by cardiomegaly, and compromised degradation of glycogen (3%); therefore glycogen accumulates leading to “megaly/ enlargement”.

Q22: A 6-month-old infant was brought to the pediatrician due to fussiness and a tender abdomen. The child seemed to do well until the time between feeding was increased to more than 3 h. The baby always seemed hungry and irritable if not fed frequently. Upon examination, hepatomegaly and enlarged kidneys were noted, and blood work showed fasting hypoglycemia. Subsequent laboratory analysis demonstrated that in response to a glucagon challenge, only about 10% of the normal amount of glucose was released into circulation, which significantly contributed to the fasting hypoglycemia. Which enzyme defect in the patient is the most likely?

- A) Glycogen synthase
- B) Branching enzyme
- C) Debranching enzyme
- D) Glucose-6-phosphatase
- E) Fructose-1,6-bisphosphatase

ANSWER: D

Symptoms indicate that have

Von Gierke disease

Q23: A muscle cell line has been developed with a nonfunctional adenylate cyclase gene. Glycogen degradation can be induced in this cell line via which of the following mechanisms?

- A) Addition of glucagon
- B) Addition of epinephrine
- C) Increase in intracellular magnesium
- D) Increase in intracellular AMP
- E) Increase in intracellular ADP

ANSWER: D

Positive regulator to glycogen phosphorylase

Q24: An individual is taking a serene walk in the park when he spots an escaped alligator from the zoo. The individual runs away as fast as he can. Glycogen degradation is occurring to supply glycolysis with a substrate even before epinephrine has reached the muscle. This is due to which of the following?

- A) Sudden decrease in blood glucose levels
- B) Increase in sarcoplasmic calcium levels
- C) Insulin binding to muscle cell receptors
- D) Decline in ATP levels
- E) Lactate production

ANSWER: B

Activation by epinephrine (fight or flight)

Q25: As the individual in the previous question continues to run from the alligator, the muscle begins to import glucose from the circulation. This occurs due to which of the following?

- A) Insulin binding to muscle cells
- B) Epinephrine binding to muscle cells
- C) Glucagon binding to muscle cells
- D) Increase in intracellular AMP levels
- E) Increase in intracellular calcium levels

ANSWER: D

As AMP levels increase in the muscle due to the need for ATP for muscle contraction, and the activity of the adenylate kinase reaction, the AMP-activated protein kinase is turned on. One of the effects of the AMP-activated protein kinase is to increase the number of GLUT4 transporters in the muscle membrane, in a process similar to the action of insulin. This enables muscle to take up glucose efficiently from the circulation when internal energy levels are low. The ability of the muscle to take up glucose under these conditions is not due to an increase in epinephrine levels, an increase in sarcoplasmic calcium levels, or insulin binding to muscle cells. Under conditions as described in the question, insulin will not be present in the circulation to bind to the muscle cells. As the muscle does not contain glucagon receptors, there is no effect on muscle when glucagon is present in the circulation.

Not included but good to know

Q26: *Streptococcus mutans*, found in dental plaque, produces acids from the metabolism of carbohydrates. Topical fluoride treatment in the dental office can slow the production of acids, resulting in the accumulation of which metabolite?

- A) Glucose-6-phosphate
- B) Fructose-1,6-bisphosphate
- C) Glyceraldehyde-3-phosphate
- D) 2-phosphoglycerate
- E) Phosphoenolpyruvate

ANSWER: D

Q27: Which of the following is the primary stimulus for insulin secretion?

- A) Epinephrine
- B) High Glucose
- C) Gastric peptide
- D) Glucagon
- E) Low Glucose

ANSWER: B

Q28: What is the immediate trigger for the dissociation of the α and $\beta\gamma$ subunits of the G-protein?

- A) Association with adenylyl cyclase
- B) Binding of GTP
- C) Dissociation of GDP
- D) Dissociation of hormone
- E) Hydrolysis of GTP

ANSWER: B

Q29: Adenylyl cyclase:

- A) Catalyzes the ADP ribosylation of proteins.
- B) Catalyzes the dephosphorylation of phospho-Ser residues on enzymes.
- C) Catalyzes the hydrolysis of ATP to ADP and Pi.
- D) Diffuses to the nucleus to function as a transcription factor.
- E) Is regulated by protein-protein interactions.

ANSWER: E

G-proteins

Q30: Which of the following will reverse the inhibition of PFK-1?

A) AMP

B) ATP

C) Citrate

D) fructose-2,3-bisphosphate

E) More than one answer is correct

ANSWER: E

Both D+A are correct

Q31: Name the pathway for glucose synthesis by non-carbohydrate precursors?

- A) Glycogenesis
- B) Glycolysis
- C) Gluconeogenesis
- D) Glycogenolysis

ANSWER: C

Q32: Which of the following are major sites for glycogen storage?

- A) Adipose tissue
- B) Bones
- C) Muscle and liver
- D) Kidney and liver
- E) Brain and muscles

ANSWER: C

Q33: Which of the following is the precursor of glycogen?

- A) Glycerol 3-phosphate
- B) Malate
- C) UDP-glucose
- D) Leucine and lysine

ANSWER: C

Q34: Name the enzyme which is used for branching of glycogen?

- A) Branching enzyme
- B) Hexokinase
- C) Phosphoglucomutase
- D) Glycogen synthase
- E) Unbranching enzyme

ANSWER: A

Q35: Erythrocytes undergo glycolysis for production of ATP. The deficiency of enzyme leads to hemolytic anemia?

- a) Glucokinase
- b) Phosphofructokinase
- c) Phosphoglucomutase
- d) Pyruvate Kinase

ANSWER: D

Q36: Which of the following glycolytic reactions produce ATP:

- A) Pyruvate kinase
- B) Phosphoglycerate mutase
- C) Adolase
- D) hexokinase

ANSWER: A

Q37: Which of the following does NOT activate glycogenolysis?

- a) Activation of adenylyl cyclase
- b) Phosphorylation of glycogen phosphorylase kinase
- c) Presence of the high AMP concentrations
- d) The release of Ca^{2+} from the sarcoplasmic reticulum
- e) Activation of phosphodiesterase

ANSWER: E

Q38: In which of the following genetic glycogen storage diseases is there an accumulation of glycogen in lysosomes due to a deficiency in the enzyme acid α -glucosidase (acid maltase)?

- A. Von Gierke disease
- B. McArdle disease
- C. Pompe disease
- D. Cori disease
- E. lipidosi

ANSWER: C

Q39: Which of the following statements about the hormonal regulation of glycogen metabolism is INCORRECT?

- A) Epinephrine stimulates glycogenolysis in both liver and muscle cells.
- B) Insulin activates glycogen synthase, promoting glycogen synthesis in the liver.
- C) Glucagon acts directly on muscle cells to stimulate glycogenolysis during fasting.
- D) AMP can allosterically activate glycogen phosphorylase in muscle tissue.

ANSWER: C

Q40: A 30-year-old male presents to the clinic complaining of fatigue and weakness during prolonged periods of fasting. He reports a history of recurrent episodes of low blood sugar levels. Laboratory tests reveal elevated serum lactate levels during these episodes. Genetic testing confirms a diagnosis of Von Gierke disease. Which of the following enzymes is deficient in Von Gierke disease, and how does this deficiency contribute to the patient's symptoms?

- A) Glucose-6-phosphatase; leading to impaired glucose release from glycogen in liver tissue.
- B) Glycogen synthase; resulting in excessive glycogen accumulation in liver cells.
- C) Phosphofructokinase; leading to impaired glycolysis and ATP production in liver cells.
- D) Phosphorylase kinase; impairing the activation of glycogen phosphorylase and subsequent glycogen breakdown in liver tissue.
- E) Liver glycogen phosphorylase; impairing glycogen breakdown in liver cells, leading to limited glucose production during fasting.

Q41: A 28-year-old male presents to the emergency department with severe muscle pain and weakness after performing strenuous exercise. He reports experiencing similar symptoms in the past during physical activities. Laboratory tests reveal elevated serum myoglobin levels. Genetic testing confirms a diagnosis of McArdle disease. Which of the following best describes the enzymatic deficiency and its clinical manifestations in McArdle disease?

- A) Deficiency in liver glycogen phosphorylase, leading to fasting hypoglycemia and hepatomegaly.
- B) Deficiency in muscle glycogen synthase, resulting in excessive glycogen accumulation in muscle cells and exercise intolerance.
- C) Deficiency in glucose-6-phosphatase, impairing glucose release from glycogen and causing fasting hypoglycemia.
- D) Deficiency in muscle glycogen phosphorylase, impairing glycogen breakdown and leading to exercise intolerance and myoglobinuria.
- E) Deficiency in glycogen debranching enzyme, causing impaired glycogen breakdown and leading to fasting hypoglycemia.

THE END

وَالَّذِينَ صَبَرُوا ابْتِغَاءَ وَجْهِ رَبِّهِمْ
وَأَقَامُوا الصَّلَاةَ وَأَنْفَقُوا مِمَّا رَزَقْنَاهُمْ سِرًّا وَعَلَانِيَةً وَيَدْرءُونَ
بِالْحَسَنَةِ السَّيِّئَةَ أُولَئِكَ لَهُمْ عُقْبَى الدَّارِ ﴿٢٢﴾ جَنَّتٌ عَدْنٍ يَدْخُلُونَهَا
وَمَنْ صَلَحَ مِنْ ءَابَائِهِمْ وَأَزْوَاجِهِمْ وَذُرِّيَّاتِهِمْ وَالْمَلَائِكَةُ يَدْخُلُونَ
عَلَيْهِمْ مِنْ كُلِّ بَابٍ ﴿٢٣﴾ سَلَامٌ عَلَيْكُمْ بِمَا صَبَرْتُمْ فَنِعْمَ عُقْبَى الدَّارِ
﴿٢٤﴾

By: Mahmoud

Aljunaidi